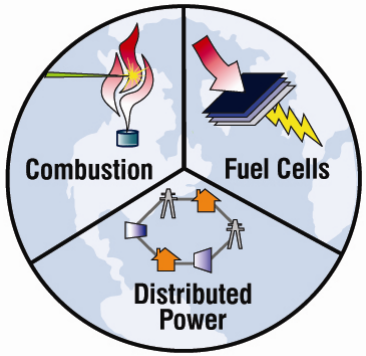
Hydrogen and Fuel Cell Technology: Status and Opportunities

IEPR Transportation Workshop No. 2

Advanced Power and Energy Program
University of California, Irvine

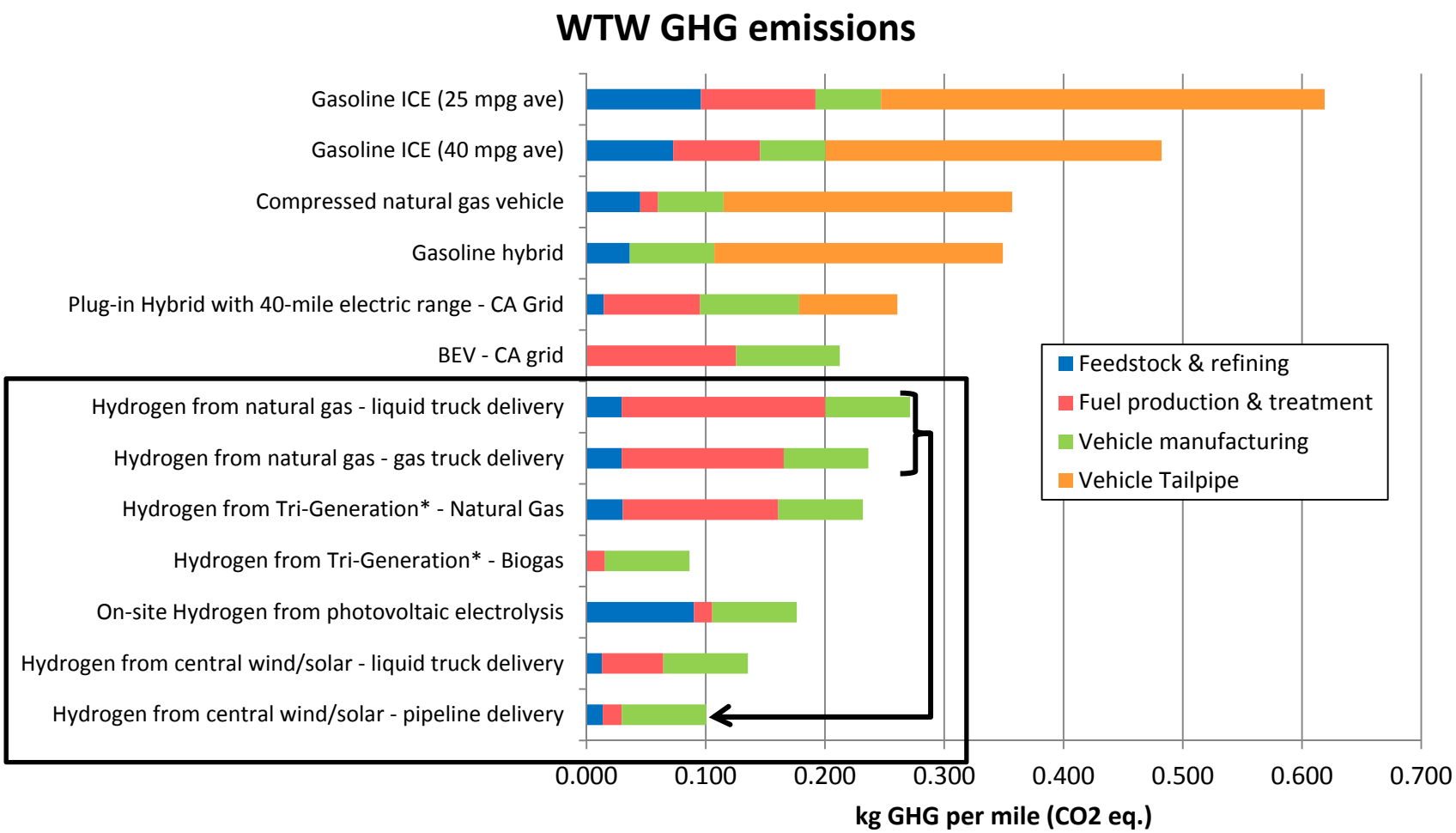


Brendan Shaffer
Technology Manager
Sustainable Energy and Transportation

Hydrogen and Fuel Cells

- **Air quality issues and climate change require ZEVs**
  - **→ FCEVs, BEVs**
- **Electrification of LDVs provides opportunities for grid support**
- **Grid will require NG and BG resources to support operation**
  - **→ Fuel Cells**
  - **→ TIGER Stations**
- **Grid will require storage to avoid excessive curtailment at high penetration**
  - **→ Battery**
  - **→ Hydro**
  - **→ Hydrogen**

HYDROGEN SUPPLY CHAIN ANALYSIS



http://www.apep.uci.edu/3/research/pdf/SustainableTransportation/WTW_vehicle_greenhouse_gases_Public.pdf

FCEV GHG Reduction Potential

Dual Sector Analysis – Transportation and Electric Systems

FCEVs provide large potential for GHG reduction

- **60% FCEV penetration at 60% Renewable penetration**

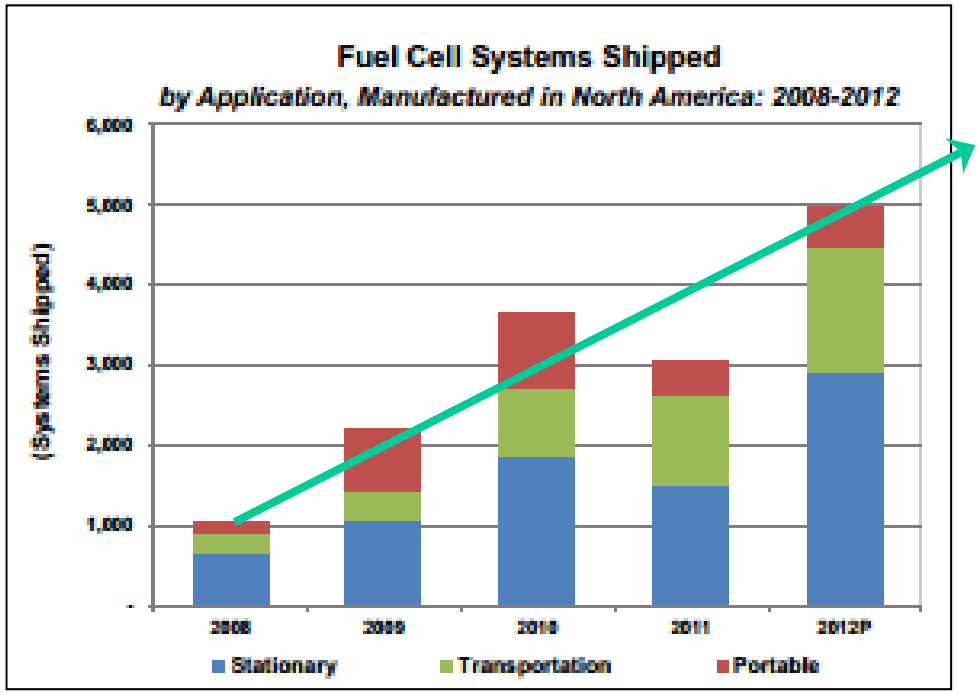
  → enables 60% reduction in GHG

Central Dispatch of Electrolysis Can Reduce Curtailment

- **H_2 Fueling Infrastructure portends large storage potential**

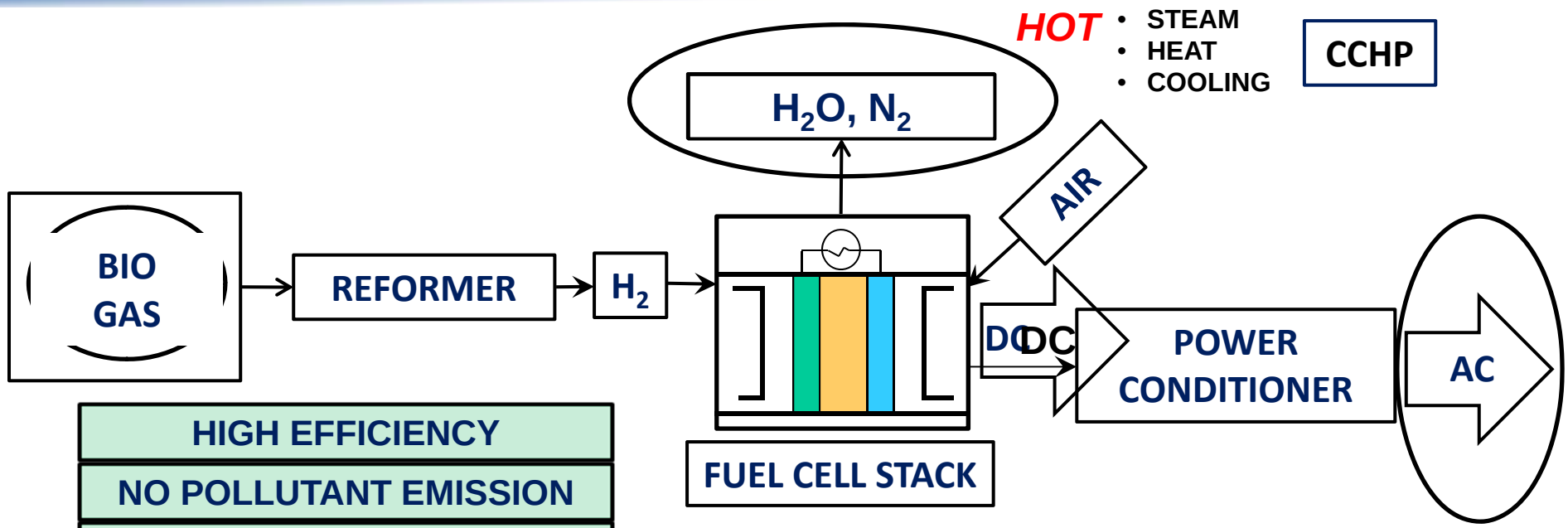
  → To support grid balancing operations at high renewable penetrations

Fuel Cell System Shipments – North America



Source: US DOE, 2012 Fuel Cell Technologies Market Report, October 2013.

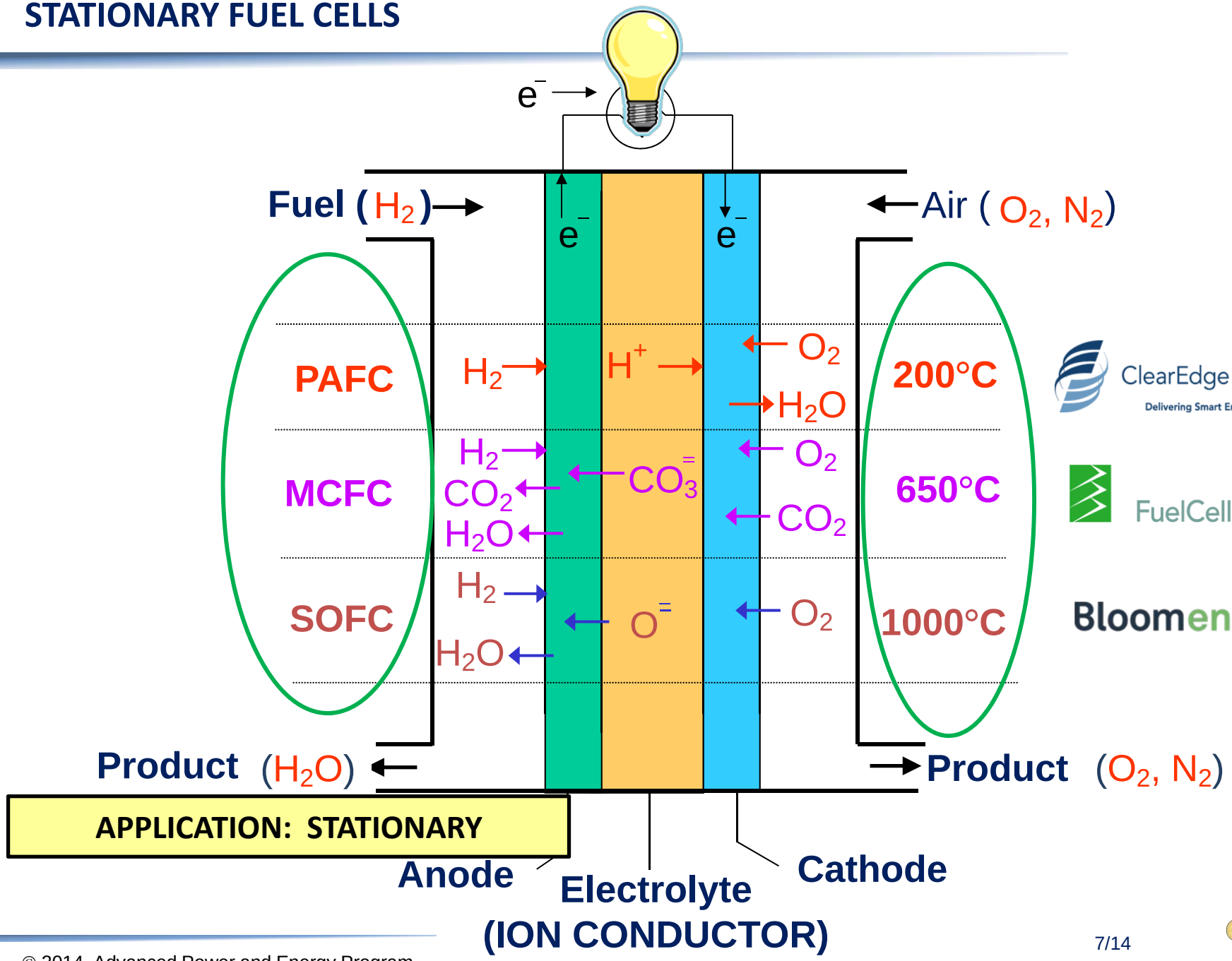
STATIONARY FUEL CELLS



- HIGH EFFICIENCY
- NO POLLUTANT EMISSION
- ACOUSTICALLY BENIGN
- HIGH QUALITY HEAT
- NO WATER CONSUMPTION
- RELIABLE, 24/7 OPERATION
- POWER QUALITY

APPLICATION: STATIONARY

STATIONARY FUEL CELLS



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Delivering Smart Energy Today™

FuelCell Energy

Bloomenergy

STATIONARY FUEL CELLS

STATIONARY FC DEPLOYMENTS

• NATURAL GAS	38
• RENEWABLE	43
TOTAL =	81 MW

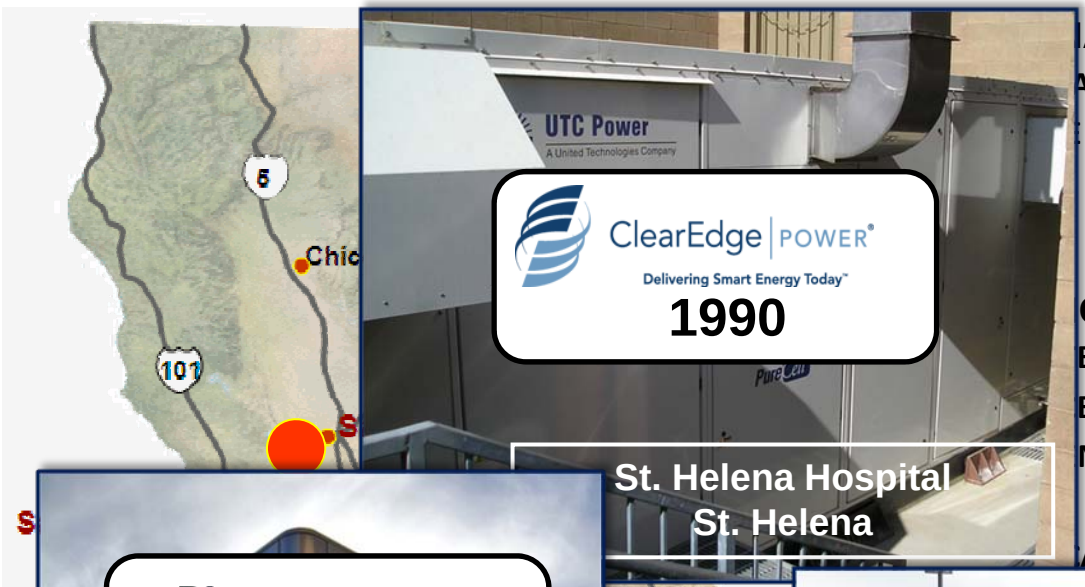
STATIONARY FC MARKETS

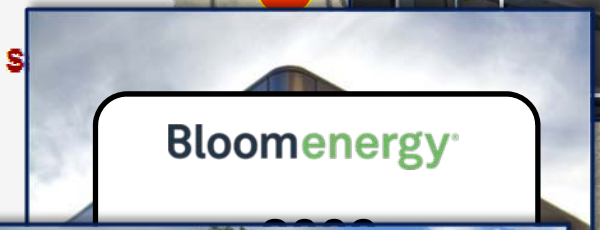
- WASTEWATER PLANTS
- FOOD PROCESSING
- GOVERNMENT
- HOSPITALS
- COMMUNICATIONS
- GROCERY STORES
- HOTELS
- BREWERIES
- UNIVERSITIES
- INDUSTRIES
- UTILITIES
- MANUFACTURING

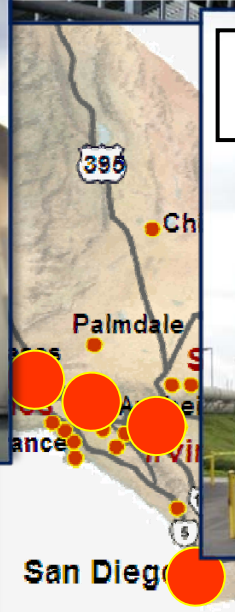
SOURCE: SGIP

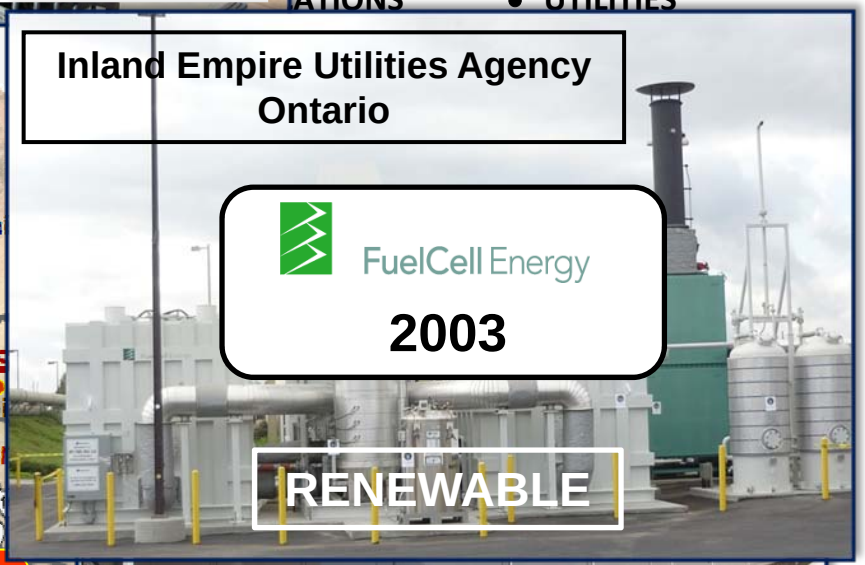
APPLICATION: STATIONARY

STATIONARY FUEL CELLS









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	43
TOTAL =	81 MW

ONARY FC MARKETS

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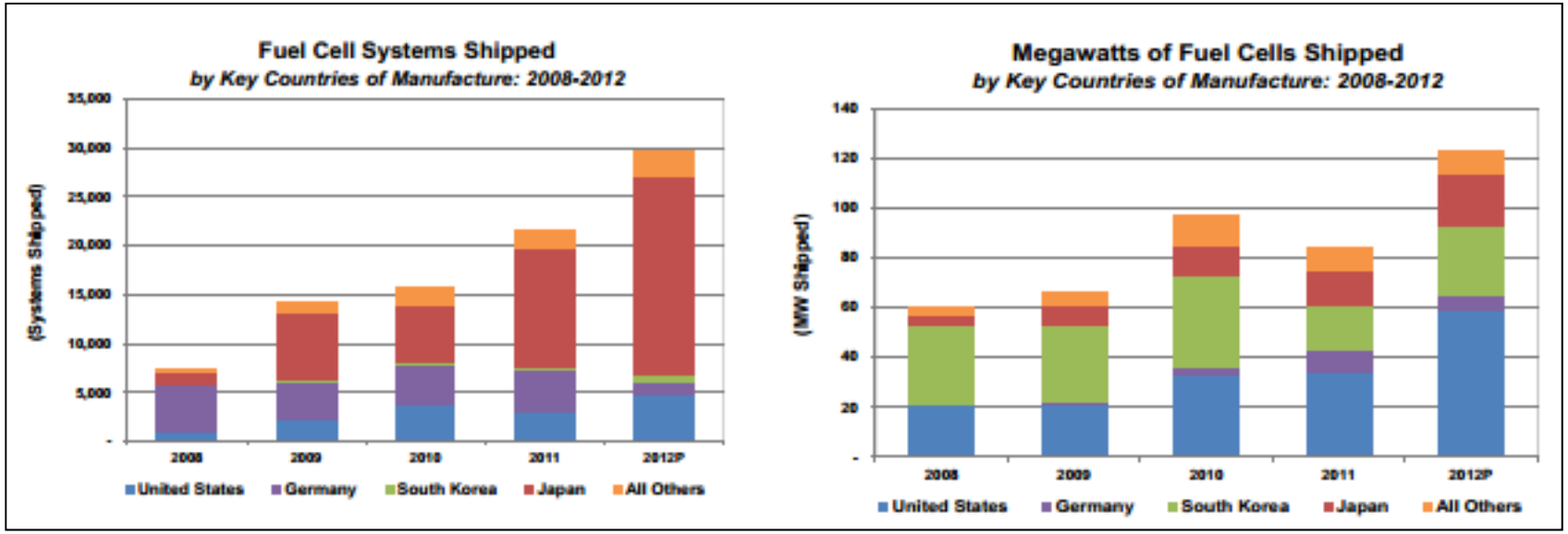
- HOTELS
- BREWERIES
- UNIVERSITIES
- INDUSTRIES
- UTILITIES

STATIONARY FUEL CELL SHIPMENTS



Source: US DOE, 2012 Fuel Cell Technologies Market Report, October 2013.

- US, South Korea, and Japan major markets
- Japan → many small units
- South Korea → a few large units

STATIONARY FUEL CELLS

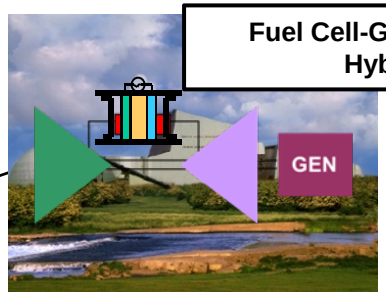
DISTRIBUTED GENERATION

TIGER STATION
(Transmission Integrated Grid Energy Resource)

RENEWABLE

CENTRAL GENERATION

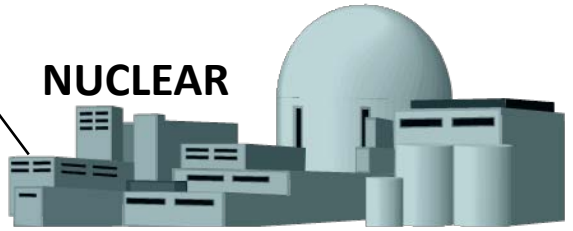
Fuel Cell-Gas Turbine Hybrid



RENEWABLE

HYDRO

NUCLEAR



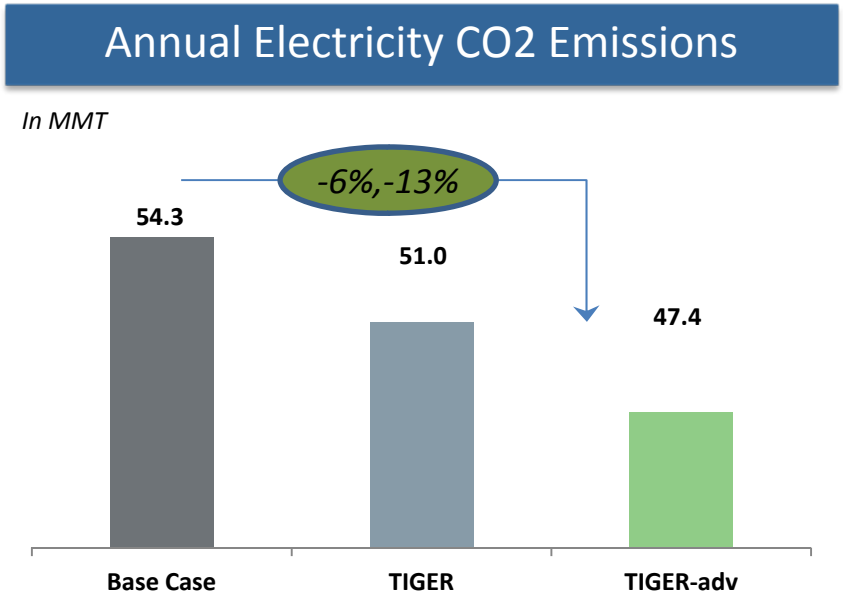
STATIONARY FUEL CELLS

STATIONARY FUEL CELLS

TIGERs to Support GHG Reduction Targets

CA Grid Modeling → CO_2 Emissions

- **Base Case: 33% Renewable Penetration, No Coal**
- **5GW Deployment of TIGER stations (NG fueled)**



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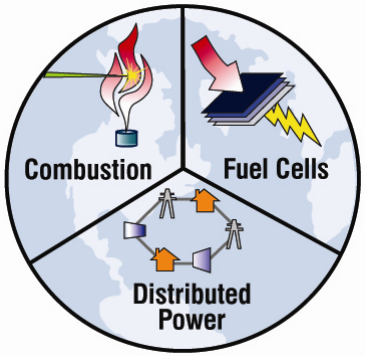

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